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# *Advanced Fuel Cycle Initiative (AFCI):* **Fuels Development Overview**

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## *Presentation Outline*

- Fuel Development Objectives
- FY'03 Accomplishments
- FY'04 through FY'07 Plans
- Conclusions
- Introduction to Technical Presentations



*Fuel development is the critical link for a successful implementation of closed fuel cycle technologies.*

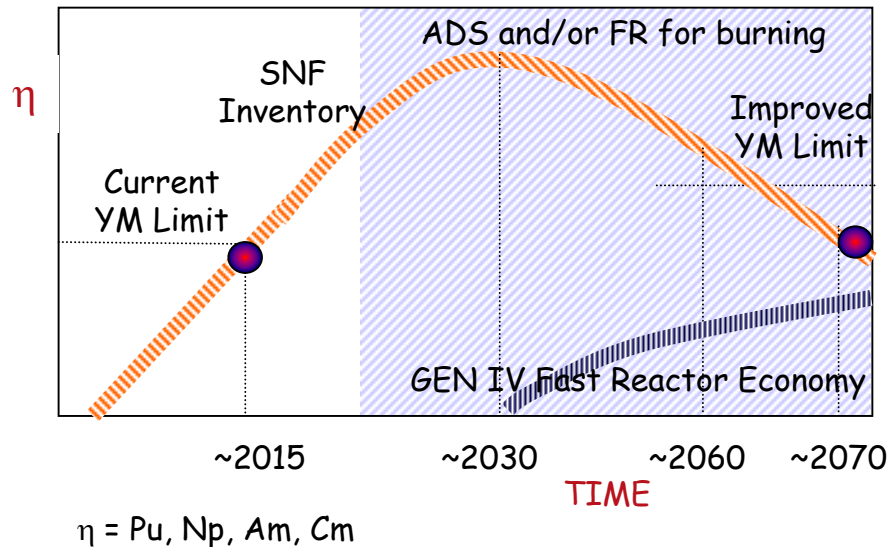


- Fuels containing high fractions of Transuranics (TRU) have never been developed and deployed before.
- High burnup needed to meet the AFCI objectives (> 20%).
- In-pile testing is expensive and time-consuming
  - U.S. has no fast spectrum testing capability
- For meaningful input during FY'07-FY09 timeframe for repository decision, an innovative approach is needed, given the schedule and budget constraints.

*Long-Term AFCI Vision and Objectives  
form the bases for the near-term fuel development plan.*

AFCI OBJECTIVES

- Optimize the use of the first repository (Yucca Mountain),
- Eliminate the need for a 2nd repository,
- Transition into a sustainable equilibrium closed fuel cycle economy (GEN IV-B).



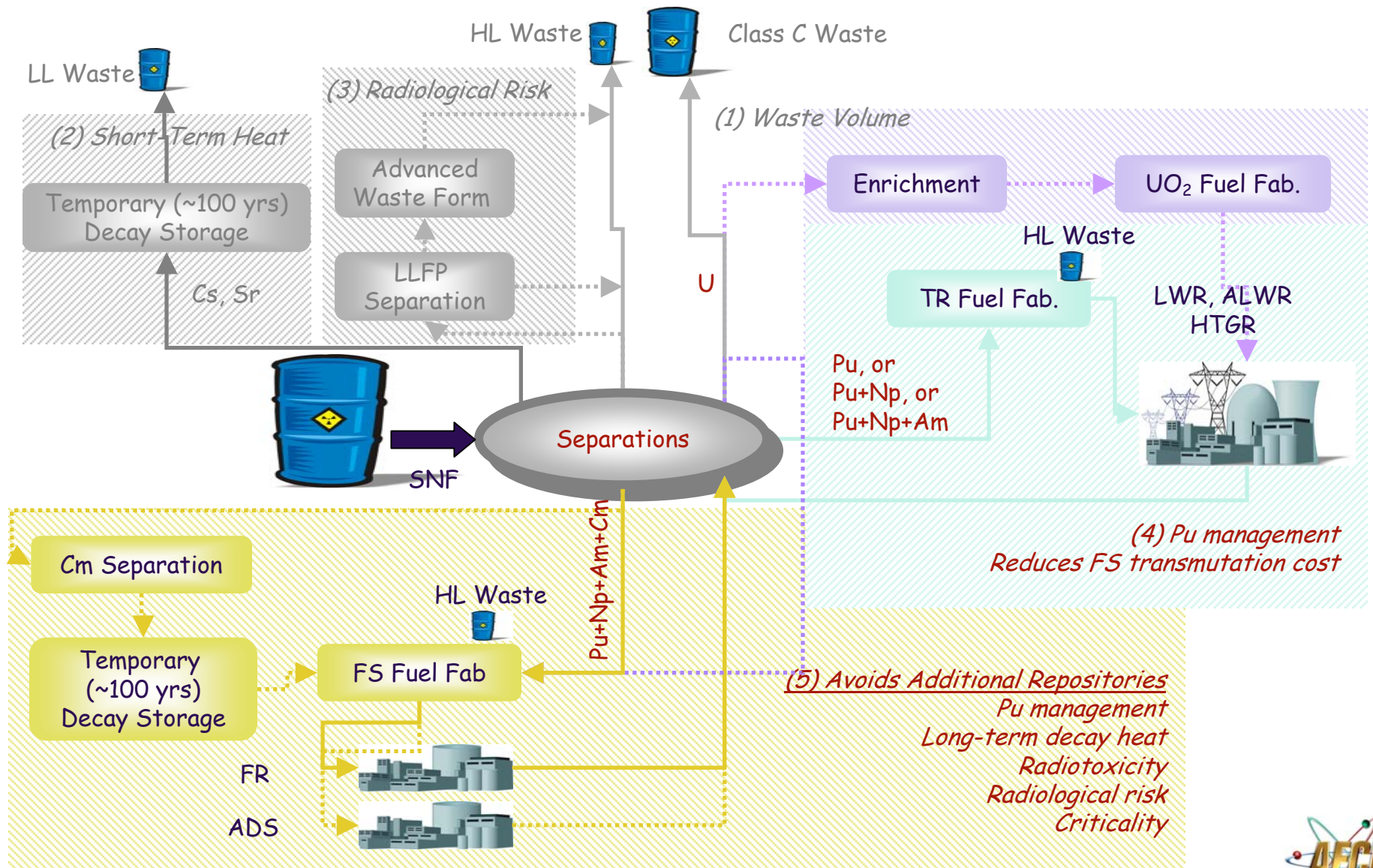
FUEL DEVELOPMENT OBJECTIVES

Complete the "proof-of-principle" on the relevant fuel forms by FY'07-FY'09

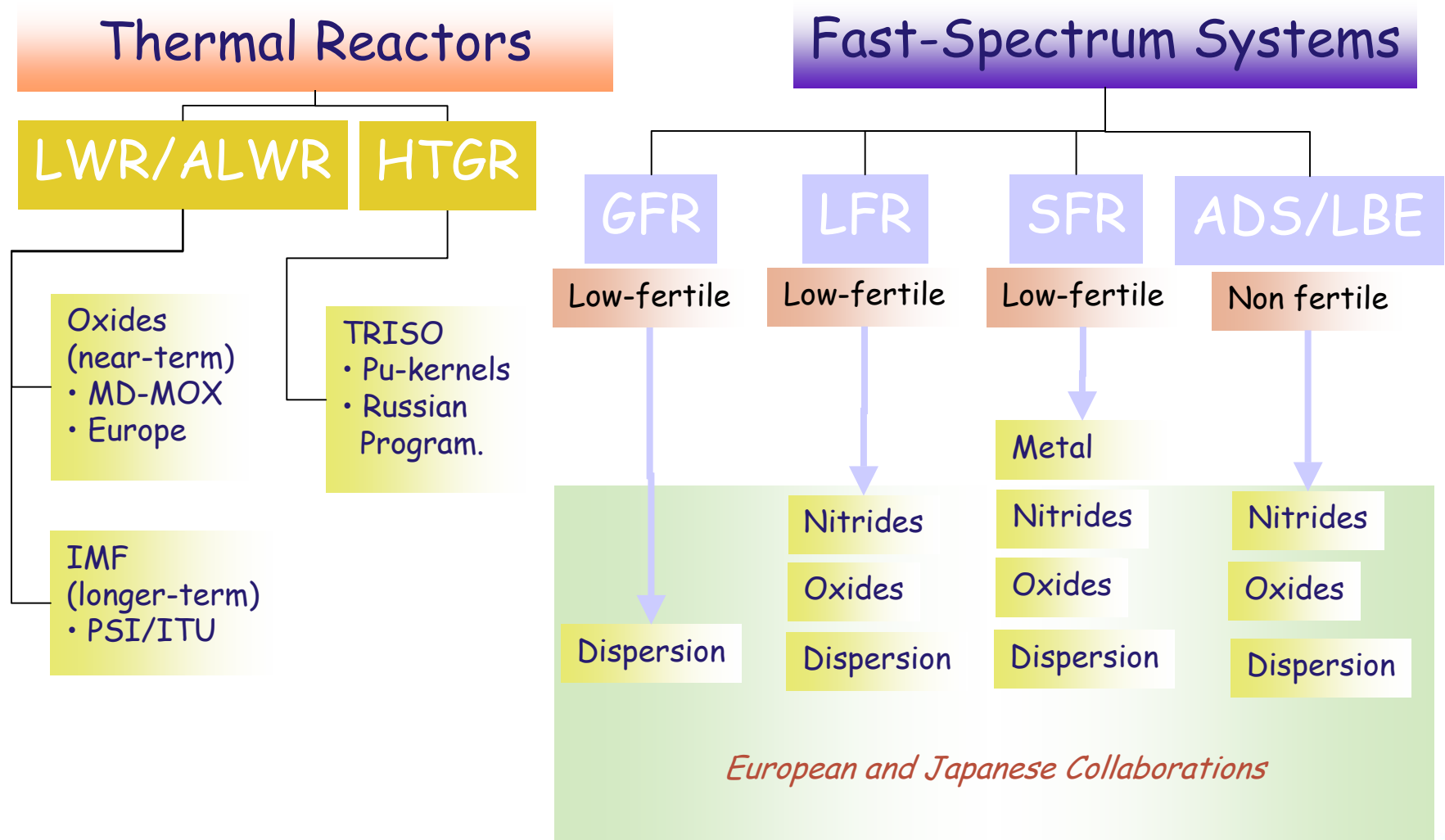
- Low-fertile fuels for low CR fast reactors
- Fertile-free fuels for ADS
- TRU bearing fuels and targets for thermal reactors
- Low-TRU fuel for fast and thermal reactors used in equilibrium cycles



# Advanced Fuel Development is needed for achieving substantial repository benefits.

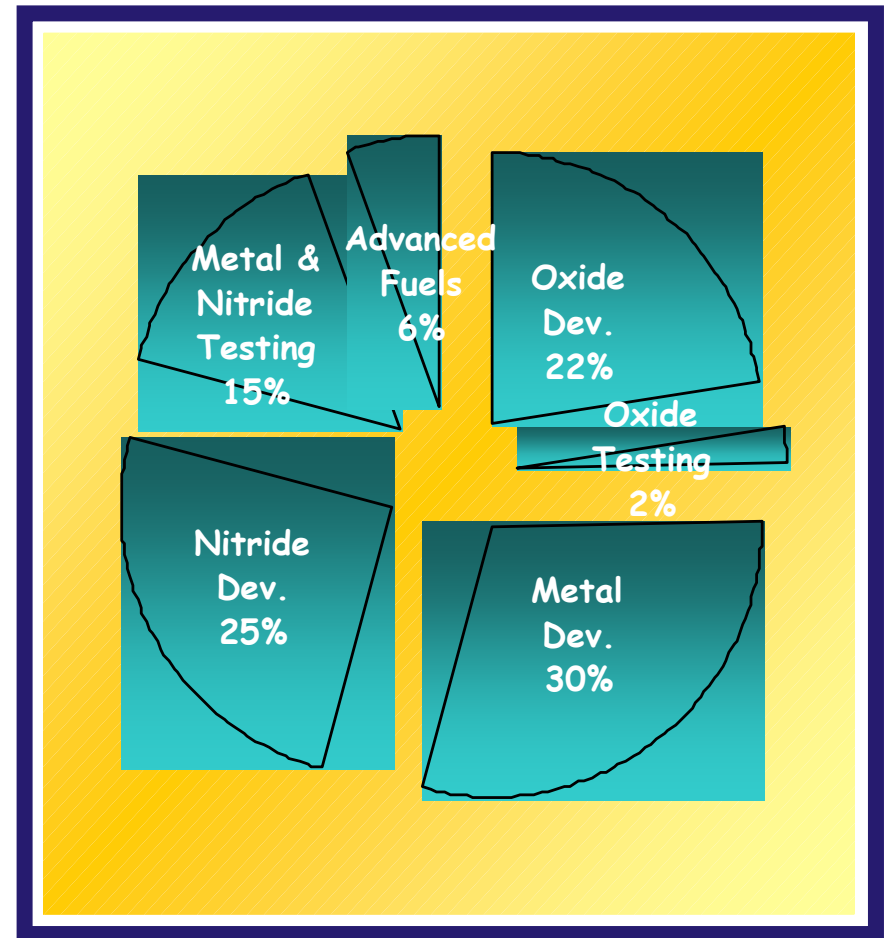


*A number of fuel options are being considered for different transmutation options.*



# *Considerable progress was made in FY'03*

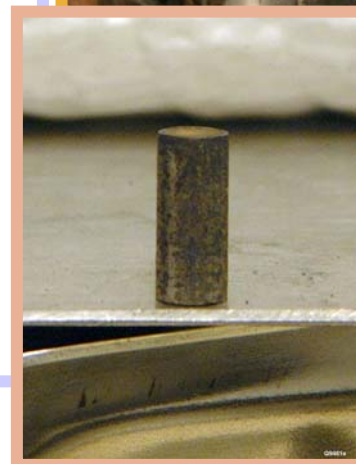
- Development of (U+Pu+Np)oxide fuels for LWR
- Development of metallic fuels for fast spectrum systems
- Development of nitride fuels for fast spectrum systems
- Patent application and development of micro-structured fuels
- Initial assessment of (U+Pu+Np)oxide fuel deployment strategy in LWRs.
- ATR irradiation for metal fuels started.
- ATR irradiation of nitride fuels starting in Nov. '03.
- ATR irradiation of (U+Pu+Np)oxide fuels starting in Nov. '03.
- FUTURIX collaboration is established
- A national fuel development working group is established and incorporated into the overall fuel development program.



TOTAL FY'03 Fuels Budget: \$9800 K

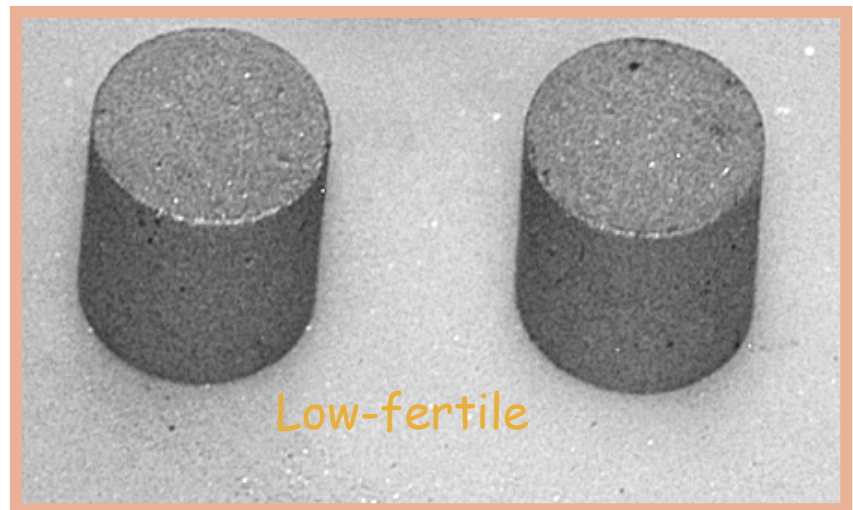
# *Metallic fuel development work is progressing very well.*

- **Fuel fabrication completed for ATR testing**
  - 12 non-fertile (Pu-Am-Np-Zr) metallic fuel rodlets for AFC-1B, -1D
  - 6 low-fertile (U-Pu-Am-Np-Zr) metallic fuel rodlets for AFC-1F
- **Non-fertile fuel alloy characterization**
  - Alloy microstructures identified
  - Phase stability (no melting) confirmed to 925°C
  - Diffusion couples vs. HT9 show good resistance to FCCI at 650°C; no low-melting compositions formed to 850°C
- **FUTURIX metallic fuel fabrication experiments complete;**
  - ability to fabricate acceptable fuels for Phénix test demonstrated



## *Nitride fuel fabrication is back on track after the first attempt resulted in fragile pellets.*

- First attempt resulted in fragile pellets
  - Inhomogeneous mixing ?
  - Low sintered densities
- Fabrication method changed
  - Solid solution in oxide state
  - Then converted to nitrides
- The new method resulted in robust pellets with the desired densities.
- Pellets with 3 low-fertile and 3 non-fertile compositions fabricated and characterized.
- Pellets shipped to ANL-W for pin fabrication and sodium bonding.
- Pellets will be inserted into ATR in Nov.'03

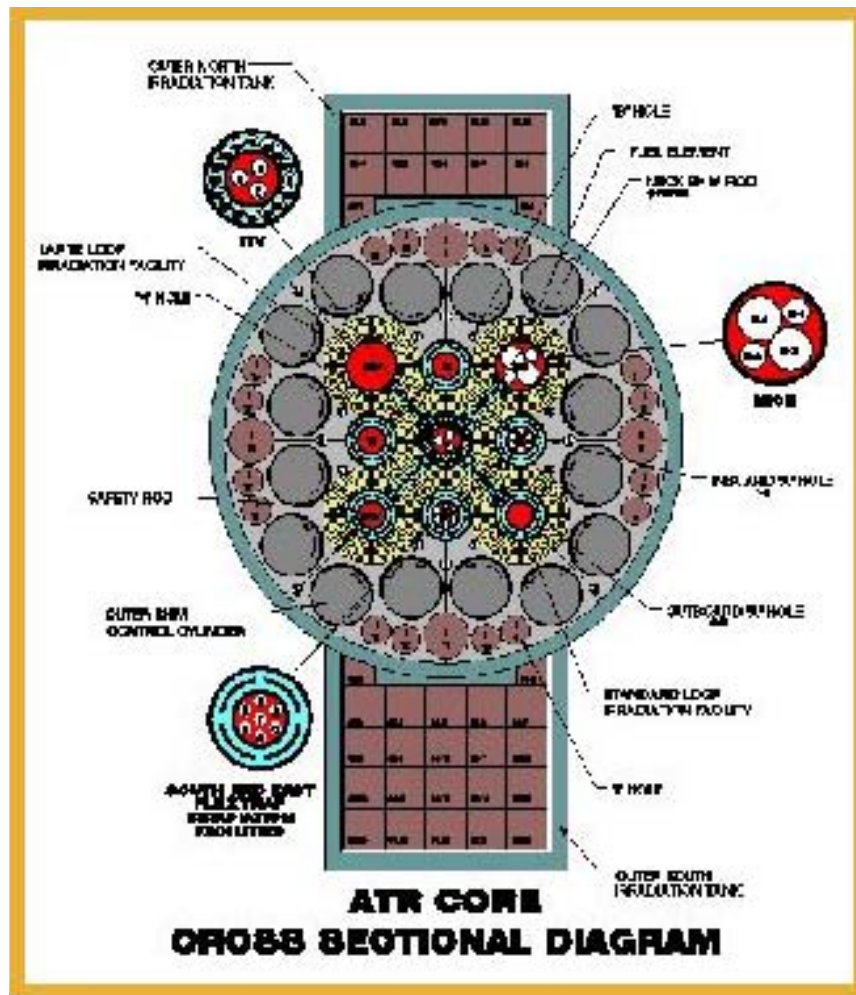


## *Oxide fuel fabrication is behind schedule but A TR insertion in November is expected.*

- A number of tests are run to determine the process parameters resulting in the targeted density ( $95 \pm 2\%$ ) for the sintered pellets.
- Pellet fabrication for the LWR-1 test series continue
  - WG MOX
  - RG MOX
  - (U, Pu, Np)oxide
- Pin welding and helium bonding capability is resurrected at LANL
  - Qualification tests completed



*ATR testing of metal fuels has started and preparations for oxide and nitride testing is on track.*



- AFC-1 (b,d) non-fertile metal fuel testing started in June
- Planning for AFC-1 (a,e,f) [non-fertile and low fertile nitrides and low-fertile metals] is continuing
  - November 03 insertion
- Planning for LWR-1 [WG MOX, RG-MOX, (U,Pu,Np)oxide] is continuing
  - November 03 insertion

## *A minimum set of deliverables are identified for input with adequate confidence to the FY'07 - FY'09 decision*

- **Fabrication process development - lab scale**
  - Pre-conceptual design for commercial plant
- **Decision on LWR fabrication process**
  - LWR fuel irradiations and comparison with MOX fuel
- **Out of pile experiments (phase diagrams, stability, structural integrity, mobility, and clad interactions)**
  - Surrogate work as appropriate
- **High burn-up (20-30 %) thermal reactor test data and analysis for fast reactor fuels**
  - PIE
- **LWR fuel testing for burnup > 40 MWd/ton HM**
- **Modeling (atomistic to continuum scale)**
  - Fabrication
  - Performance
  - Safety
- **Low burn-up fast spectrum testing initiated in Europe**
  - completed in FY10
- **Feasibility study of TRISO fuel design for MA kernel complete**  
*Considerable reliance on International Collaborations on metal, oxide and dispersion fuels*

### MODELING

- **FRAPCON**
- **TRANSURANUS (MOX)**
- **PARFUME (TRISO)**

### IRRADIATION TESTS

- **ATR**
- **PHENIX (France)**
- **HFIR**

### PIE

- **ANL Hot-cells**
- **ORNL Hot-Cells**
- **LANL Hot-Cells**

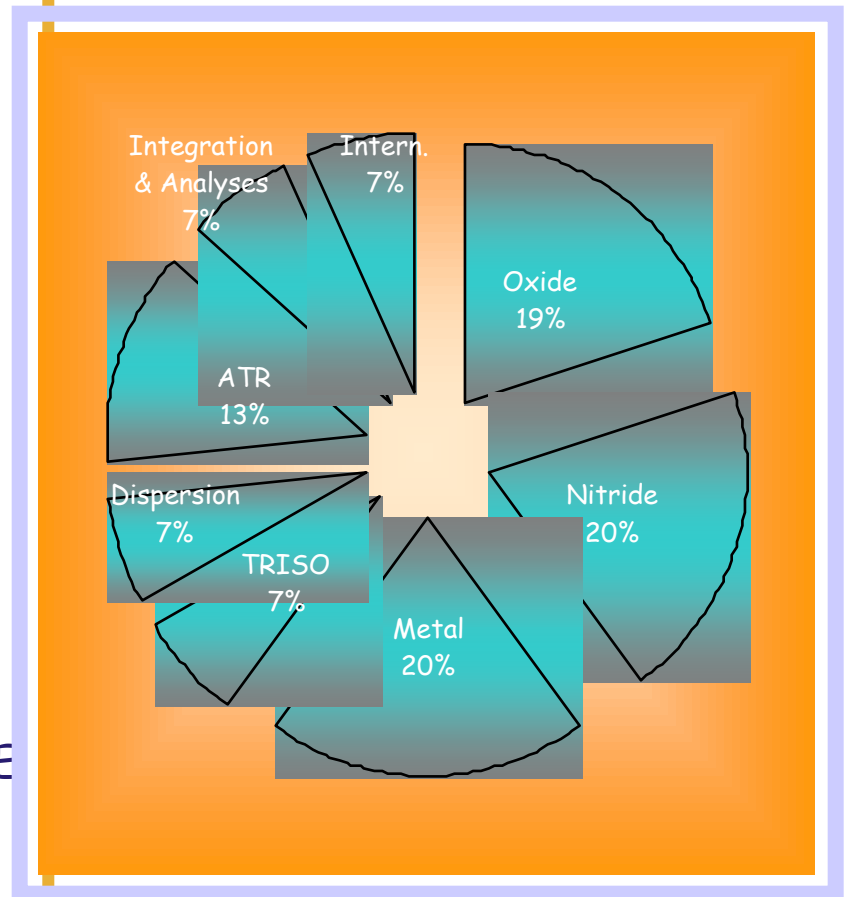


*The minimum set of milestones result in some short comings in some important areas*

- We will demonstrate feasibility but not an optimized technology for the fuel deployment
  - Uncertainty in transmutation efficiency and cost
- Insufficient data for a statistical assessment
- For some of the fuel types, heavy reliance on International data and assessments
- No investment in infrastructure
  - e.g. fast spectrum test facility
  - If we have to deploy, fuel qualification phase will be delayed to wait for infrastructure development

# *The initial FY'04 planning for fuel development is completed*

- Metal and nitride work continues with emphasis on
  - FUTURIX preparations
  - Modeling
  - AFC-1 PIE
- Oxide work continues with emphasis on
  - Fabrication process evaluation and ATR testing
  - Modeling
- Initiate dispersion fuel work
  - Emphasis on FGR fuel evaluation
  - International programs
- Re-initiate TRISO fuel work
  - Modeling
- Continue ATR testing until CIC
- FUTURIX collaboration continues & MILE collaboration starts



Assumed budget for fuels ~ \$15M

## *In conclusion,*

- **FY'03 has been and continues to be a productive year**
  - Considerable progress in metal, nitride and oxide fuel development and testing
- **Multi-institutional fuel development working group (FDWG) is well established, working very well together and looking forward to new challenges in FY'04.**
- **Additional University involvement in fuel development is expected in FY'04 and beyond.**
- **A plan for minimum level of required development to be used as an input to repository decision in FY'07-FY'09 is developed.**
  - This plan provides adequate data for decision but delays deployment if decision is in favor of deploying transmutation
  - The plan is a "science-based" approach with more modeling and laboratory tests and targeted in-pile tests in ATR (HFIR?)
- **The 5-year plan assumes ~\$15 M for fuel development in FY'04 assuming the overall budget is consistent with Senate mark.**
- **We are looking forward to extending International collaborations in FY'04 and beyond**



*Detailed technical talks are provided  
for the major FY03 efforts.*

Status of Oxide Fuel Development	Bob Margevicius (LANL)
Status of Nitride Fuel Development	Bob Margevicius (LANL)
Status of Metallic Fuel Development	Steve Hayes (ANL)
Status of ATR Irradiation Tests	Richard Ambrosek (INEEL)
AGR TRISO Fuel Development Status	Madeline Feltus (DOE-NE)